MINERALOGY.—*Methods for distinguishing natural from cultivated pearls.*[1] F. E. WRIGHT, Geophysical Laboratory.

Efforts have been made for several centuries to induce pearl-growing oysters and mussels to produce pearls comparable in quality and size to the "natural" or "normal" pearls found by pearl divers in different parts of the world and known to the trade as fine pearls. It is a simple matter to provoke formation of "blisters" and baroque pearls, but only recently has a Japanese, Dr. K. Mikimoto, succeeded in developing a suitable method for inducing pearl oysters to grow pearls which are spherical in shape and similar in external appearance to fine pearls. His process, which has been patented, is essentially the following: A pearl oyster is first removed from its shell; from its outer, shell-secreting mantle, a patch is dissected off, large enough to enclose, as a sac tied at the neck, a foreign nucleus, such as a bead of mother-of-pearl or even an inferior pearl. Each bead thus enveloped by the shell-secreting epidermis is embedded in the sub-epidermal tissues of another live oyster, which, after proper treatment of the wound, is returned to its native habitat where in the course of a few years a coating of pearl around the inserted bead may be deposited. The success of this process is due, as was first emphasized by Dr. H. Lyster Jameson,[2] to the "presence, in the sub-epidermal tissues of the oyster, of a closed sac of the shell-secreting epidermis and not to the presence of an irritating foreign body" as has been often supposed.

The pearls thus induced by the Mikimoto process are now on the market and pearl merchants have had difficulty in distinguishing natural Japanese pearls from the cultivated pearls of Mikimoto.

A short time ago the writer's interest in this problem was aroused by Dr. G. F. Kunz of New York who kindly loaned him, for examination and comparison, examples of the Japanese cultivated pearls and of fine pearls. In the Japanese pearls the centers were without exception mother-of-pearl beads, and the methods described below are based in large part on the ability of the observer to recognize the mother-of-pearl nucleus.

Mother-of-pearl or nacre substance is composed of alternate laminae or layers of calcium carbonate and of a horny organic substance called conchiolin. In most of the mother-of-pearl shells examined by the writer the carbonate is the mineral aragonite in the form of needles elongated parallel with the acute bisectrix and oriented perpendicular

[1] Received June 19, 1923.

[2] Proc. Zool. Soc., I, 140–166. 1902; Nature, Jan. 22, 1903, p. 280; Nature, May 26, 1921, p. 397.

to the pearly layers. The iridescence (luster, orient) of the pearl is due to interference of waves of light at the different pearly layers[3] which are remarkably uniform in thickness; the combined thickness of the carbonate layer and the conchiolin layer is 0.0004 to 0.0006 mm. or about equal to a wave length of light. At the surface of each layer some light is reflected and this interferes with a certain part of the incident light. The final result is the reflection of a relatively large amount of light and a correspondingly low transmission of the mother-of-pearl for rays of light incident normal to the pearly surface. The reflecting power on sections normal to the layers is appreciably less and the transmission is relatively much higher. This difference in reflecting power and in transparency with direction is easily seen on a bead of mother-of-pearl. Held in one position the characteristic pearly luster appears; turned through 90° the luster is less and the bead is noticeably more transparent. In strong sunlight this difference is still more striking. If now the bead of mother-of-pearl is enclosed in concentric layers of pearly substance, the lack of transparency of these layers, especially when viewed along a diametral direction, tends to mask the mother-of-pearl phenomena; but if the cultivated pearl be viewed under proper conditions of illumination the phenomena characteristic of mother-of-pearl are readily seen.

1. *Test in reflected light.* To test a pearl by this method examine the pearl first in reflected light. Stand with the back to the window, to the sun, or to some strong source of light. Hold the pearl so that it is illuminated by rays from the rear and observe the change in intensity of reflected light as the pearl is rotated. This rotation is accomplished most readily if the pearl is mounted on a string or a piece of thin wire. At the position for which the characteristic mother-of-pearl sheen is reflected by the nacre-bead, this sheen is clearly visible shining out from inside the pearl (Fig. 1c). It appears again on rotation of the pearl through 180°. After a little practice the eye catches quickly this phenomenon. Its appearance, which adds to the interest of the pearl, brands the pearl definitely as a cultivated pearl with a mother-of-pearl center.

2. *Test in transmitted light.* The pearl is examined either in air or while immersed in a liquid, such as water; the purpose of the liquid is to reduce to a minimum the amount of light reflected at the surface and thus to render more easily visible any lack of

[3] Optics. Sir David Brewster, pp. 137–149. 1853: A H. Pfund, *The colors of mother-of-pearl.* J. Franklin Inst., 453–464. 1917.

homogeneity within the pearl. As a rule the liquid is unnecessary and is rarely used because it may possibly stain the pearl. The method consists in sending a narrow beam of intense light into one side of the pearl and noting any differences in illumination, along different directions in the opposite half, which are due to a foreign nucleus such as as a mother-of-pearl bead. Adequate illumination is attained by imaging on the pearl an intense light source, such as a pointolite bulb or a small arc or the sun, with the aid of a condensing lens

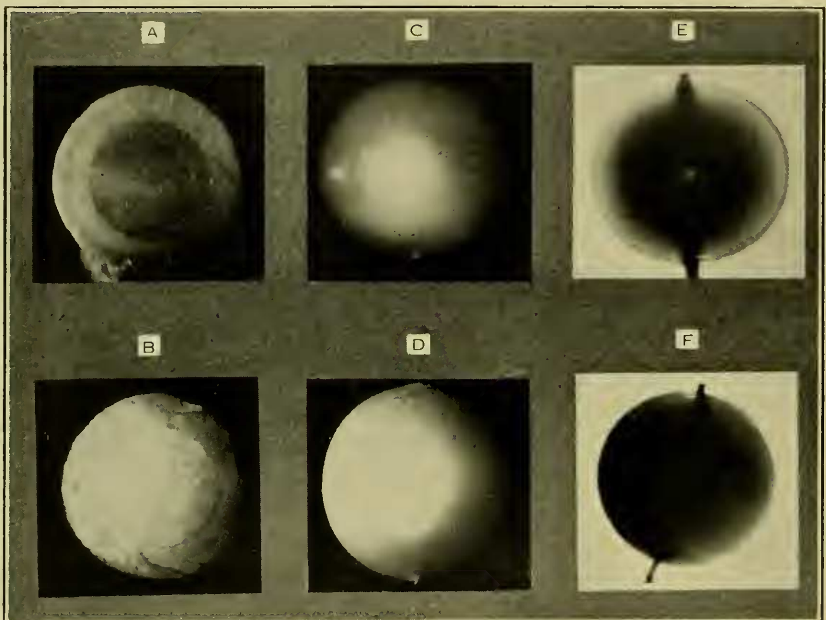

Fig. 1. *A*. Diametral section of cultivated pearl showing mother-of-pearl bead illuminated from the side. Magnification 5×. *B*. Section of the same pearl viewed in reflected light. *C*. Cultivated pearl viewed in reflected light showing on the left the illuminated spot due to the mother-of-pearl sheen. *D*. Natural pearl illuminated from the side. *E*. Cultivated pearl illuminated by strong light from the rear. *F*. Natural pearl photographed under the same conditions of illumination.

(Fig. 2). If possible a vertical beam of light travelling upward is used. To avoid extraneous light, the pearl is placed on a thin sheet of metal directly over a small hole (*c* Fig. 2) drilled through the metal. The hole serves as an aperture, somewhat smaller in diameter than the pearl.[4] The intense beam of light passes through the aperture, impinges on the pearl, and illuminates its interior. The only light that reaches the

[4] A special piece of apparatus for the testing of pearls by this method is now being made available by the Bausch and Lomb Optical Company of Rochester, New York.

observer is that which passes throught the pearl. Any differences in degree of transmission between center and periphery of the pearl are then clearly visible and enable the observer to see the shadow of any foreign nucleus. If the nucleus consists of mother-of-pearl the transparency differences for different directions of transmission through the bead can be observed on rotating the pearl. In natural pearls the central part appears opaque because of the high reflecting power normal to the concentric lamellae; but this central disk is not so large as the bead of a cultivated pearl and does not change its appearance as the pearl is rotated.

Under these conditions of illumination the pearl can be examined by the observer looking at it from any direction, either facing the source of light or at right angles to the incident beam or from any

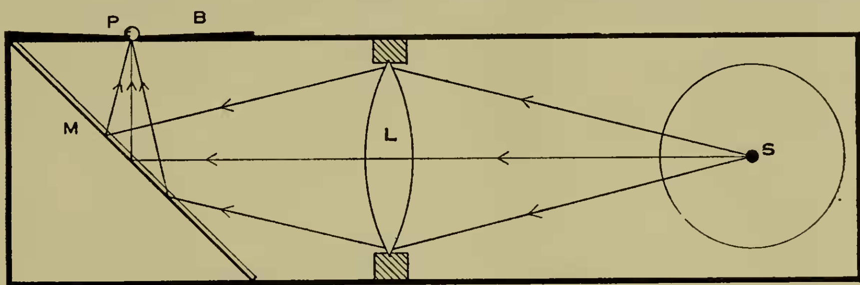

Fig. 2. Simple device for distinguishing cultivated pearls from natural pearls. *S.* strong point source of light; *L.* aspheric condenser lens; *R.* reflecting mirror; *B.* metal plate in which a small hole 3 mm. diameter has been drilled. Above this aperture, which can be made of different size by means of a sliding stop diaphragm, the pearl, *P*, rests.

intermediate position (Fig. 1, e.f). It is advantageous thus to examine the pearl end on and from the side because, as it is turned about, certain differences in homogeneity are more readily seen along one direction than another. Under these conditions any flaws or imperfections in the pearl, whether natural or cultivated, are clearly shown. Cultivated pearls exhibit many imperfections and patches of different reflecting power and degree of transparency. Many natural pearls show minute spots and irregularities, but the best pearls are free from flaws of any kind.

3. *Examination of the walls of the hole drilled through the pearl.* Illuminated by a strong beam of light from the side, the walls of the hole drilled through the pearl exhibit the boundary between the outer pearl substance and the mother-of-pearl nucleus. This is rendered visible not only by a difference in intensity of illumination but also in color; the pearl shells are noticeably blue in color while the nucleus

is tinted yellow. In this examination the pearl is supported on a wire extending into the hole to the center of the pearl. The wire is held between the thumb and first finger in an upright position and the hole is examined with the aid either of a magnifying glass, a microscope, or a binocular microscope. The work of Galibourg and Ryziger[5] has demonstrated that with the aid of a microscope and a suitable mirror it is possible to detect differences in homogeneity of the material exposed along the hole drilled through the pearl. The mirror, which they employ, is the top of a mercury column, like that in a thermometer tube. The mercury is forced up through the hole in the pearl by a delicately adjusted apparatus and the reflections from the top of the mercury column are observed through a strong magnifying system (microscope or binocular). This method is said to be very successful. The pearl is illuminated by a strong light from the side. The difference between the darker center and the enclosing pearl shell, especially at the boundary between the two, is clearly shown in the curved mirror. In applying this method, the writer has had difficulty in obtaining a uniform movement of the mercury column because of the capillary dimension of the hole and the tendency for slight obstructons to bar temporarily the passage of the mercury; in passing an obstruction, the mercury tends to flow rapidly and to advance by jumps rather than smoothly. The apparatus moreover is complicated and for purposes of this sort the handling of mercury is rarely satisfactory.

The following simpler and equally efficient method may serve the same purpose. In place of the mercury column a small bead fused on the end of a pure gold wire is used. A short piece of fine gold wire (0.2 mm. diameter and about 1 cm. long) is satisfactory; the bead is produced by holding the end of the wire in a Bunsen flame for a time sufficient to melt down the tip and form a small bead. The gold bead thus produced is much smoother and presents a more perfect reflecting surface than does a silver or platinum wire bead, or the surface which can be formed by grinding and burnishing the end of a fine steel needle in a lathe. The gold bead can be silver plated if desired. In the writer's experience, however, this is unnecessary. The wire is held stationary in a vertical position with the bead uppermost between the thumb and forefinger, the pearl to be examined is held by the other hand and slid over the stationary wire so that the wire passes through the drilled hole. If desired, the wire and also the pearl can be held by mechanical device and the pearl moved up or down by a screw. The pearl is illuminated by a strong light from the side. During this

[5] The Watchmaker, Jeweler, Silversmith and Optician, pp. 1821–1823. 1922.

operation the reflections from the stationary bead are observed through a low power microscope or binocular magnifying 25 to 50 diameters. The various phenomena described by Galibourg-Ryziger are shown equally well by this method. The preparation of beads of different sizes to fit different holes is a matter of only a few minutes.

This method has the advantage over the first two methods in that it may be used to distinguish between normal pearls and cultivated pearls with a pearl center.

In any case, test by all three methods should be applied, the one to serve as a check on the other. These tests are not time-consuming and in most instances lead to definite results.

4. *Test in ultraviolet light.* Recently C. S. Fox (Journ. Indian Industries and Labor, **1**^{3}: 235; Chemical News, **125**, 67–68. 1922) has found that in ultraviolet light both natural and cultivated pearls fluoresce, with the difference, however, that the Persian Gulf pearls are opaque to ultraviolet light whereas Japanese pearls, both natural and cultivated, have a translucent opalescence. He considers that because the cultivated pearl has a nucleus which comprises from 0.5 to 0.9 of the total volume of the pearl and which is of inferior material (mother-of-pearl) whereas a natural pearl is made up of concentric layers of pearly substance from center to periphery, the cultivated pearl is an inferior article and is not to be considered in the class with natural pearls. In view of the difficulty in distinguishing cultivated pearls from natural pearls, he proposes that all Japanese pearls, both natural and cultivated, which show a translucent opalescence in ultraviolet light, shall be considered of inferior quality. The writer has repeated the test of Fox with the new fluorescent microscope of the Bausch and Lomb Optical Company and has noted that the translucent opalescence described by Fox is not so clearly and distinctly shown that uncertainty may not arise regarding the kind of pearl under test, whether Indian or Japanese. It would seem unwise to adopt this suggestion because pearls may at some future time be cultivated in the waters of the Persian Gulf and then the rule would fail to accomplish the desired result, and produce confusion worse than ever.

BOTANY.—*A new genus of senecioid composites.* P. A. RYDBERG, New York Botanical Garden. (Communicated by PAUL C. STANDLEY.)

The genus *Clappia*, named after Dr. A. Clapp of New Albany, Indiana, was described by Dr. Gray in the Botany of the Mexican Boundary Survey. Dr. Gray placed the genus in the tribe Helenieae,